Final Report submitted to
NOAA's Human Dimensions of Global Change Research (HDGCR) Program

Title: Decision Making under Risk of Extreme Climate Events

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Preliminary Materials

A. Abstract

Evidence from the field of seasonal climate forecasting applications has shown that it is difficult to relay new climate information to users in a format that is useful, partially because cognitive biases in perceptions of uncertain, probabilistic climate information may inhibit good decision making. This lesson has useful application in the area of promoting adaptation to climate change. Expectations for the coming season or seasons, whether based on climatology, a seasonal forecast, or knowledge of climate change, are susceptible to cognitive biases, and decisions arising from these expectations are influenced accordingly. Observational and model-based data support the assertion that climate is changing, making critical the societal goal of improving our ability to respond to new climate information. Observed changes are manifest as increases in extreme events, which influence mental models of climate and, in turn, shape climate-sensitive decisions. This proposed research draws on insights gained in the arena of seasonal forecasting, taking advantage of current responses to extreme climate events, to better understand and address the ways in which mental models of climate influence adaptation to climate change.

Given the tight linkages between farming systems and climate, we are utilizing an agricultural setting for this work in the expectation that mental models of climate among

farmers should be particularly well-developed and will lead to useful results. Our work was conducted in the Northeast US, a region without seasonal forecast skill, which ensures that mental models of climate are based solely on experience and expectations for climate change. Using written surveys and in-person interviews with dairy and vegetable farmers, we mapped mental models of important climate events, including expected ranges and return frequencies, and identifying the relationship between mental models and resource management decisions. Farmer perceptions were compared with distributions of observed climate based on historical records drawn from local stations. To address cognitive biases identified through interviews, we will develop and deliver instructional materials in workshop and focus group settings. Additional visits with farmers following extreme events that occur during the study period will provide opportunities for evaluating instructional materials, and furthering our understanding of risk management and decision making under climate uncertainty.

B. Objective of Research Project

The primary objective of this work is to understand if cognitive biases of farmers in Eastern New York State impede their ability to adapt to climate change or if, in fact these biases facilitate adaptation. Given the evidence of increased variability in rainfall and temperature events in the Northeast US, coupled with the phenomenon of exaggerated emphasis on recent climate events in people's perception of what is "normal", we expect to observe some adaptive responses occurring already. Adaptation to increased frequency of extreme events is likely to fall into two primary categories – the use of insurance instruments to protect against routine losses (we assume this approach implies no expectation of increasing extremes), or by increasing resilience in production methods, increasing diversity of farm products, and/or marketing arrangements (which is more likely to be associated with concerns about future climate extremes). This work seeks to improve our understanding of the factors which influence farmer decision making in the context of climate risk, and based on this understanding develop educational materials to facilitate decisions related to climate change.

C. Approach

Approach: Our research team (an agronomist, Phillips, a psychologist, Krantz, and a climatologist, Lyon) has designed and delivered both written and in-person surveys to a sample of the farming community in Eastern NY, primarily from the population within approximately 100 miles of Albany. Selecting from this group, we held two workshops, presenting information on climate variability, climate change, and decision making in the context of climate risk, and evaluate decision making aids developed.

Population: In the Northeast US, skill in seasonal climate forecasts is too low for practical application. This lack of a seasonal forecast simplifies our study because expectations for the coming season are based solely on experience and knowledge of climatology, and possibly perceptions of the influence of climate change. We limited the study to Eastern New York State. Dairy, fruit and vegetables are important products for New York State (NASS, 1997). Our survey addressed a range of producer groups rather than one segment in order to protect against producer biases.

Data collection: In year one, a baseline survey was mailed to approximately 250 farm families, with a return rate of approximately 25%. In year two, an additional 300 surveys were mailed. A total of 118 surveys were returned. The survey covered demographics, general information about the farming system, length of time farming, perceptions about and responses to past extreme events and expectations for the future of their operation. This set of data served two purposes. First, from this larger sample, we have been able to estimate general perceptions of climate change and risk management strategies, and second, we used the responses to identify a set of farmers willing to participate in the in-person interviews

Historical records of daily weather data have been secured for a number of sites in the region. We performed simple statistical summaries of the distribution of climate variables identified by farmer participants.

Climate education activities and materials: Two workshops were conducted. The first year workshop took place in Greene County in January 2006 and the second further north in January of 2007. The objectives of the workshops are 1) to provide a forum to present new information about climate, climate change, and information resources that exist; 2) to test new visualization techniques that address cognitive biases in perception of climate and to aid in decision making with new climate information; and 3) to conduct group exercises in decision making with uncertain information, using a contingency planning approach, designed to explore multiple outcomes and implications of various trade offs. Based on an analysis of the data collected and the two workshops conducted, a booklet entitled "Hudson Valley Climate and Farm Management: A Reference Guide" was developed and distributed to all participating farmers (118) and to the county Agricultural Cooperative Extension Offices.

D. Matching Funds

The project benefited from a contribution of approximately 3 weeks of time per year by the two co-investigators, Brad Lyon and Dave Krantz.

II. Interactions

A. *Decision Makers*: Our study rests on the collaboration of farmers in Eastern New York State, from whom we benefited in increasing our understanding of decision making under climate risk, and who we hope will benefit from the process of interaction over the three-year study. The primary farmers to benefit from the work will be those who agree to work with us for the duration of the study, but we expect there to be a ripple effect as they interact with others in their community. Furthermore, Cornell Cooperative Extension agents in the counties where we are working will participate in the workshops.

B. *Climate forecasting community*: In addition to Brad Lyon, one of the co-investigators from the IRI, others at the IRI have shown interest in discussions with us regarding the information presented to farmers on climate change and variability. Lisa Goddard, in particular, is meeting with the P.I. to discuss the implications of both climate change model output for the northeast and analysis of

trends in historical data. Additionally, we expect to continue to share our results at workshops and climate research meetings.

C. *Other research efforts*: This project is tightly coordinated with the work underway by the NSF-funded Center for Research in Environmental Decisions (CRED) at Columbia University. The team has been granted funds for additional work beginning in 2007 through CRED and is participating in annual workshops, exchanges of materials and instruments, and discussions with the other researchers funded through CRED. Dave Krantz is one of the PIs at CRED and forms the tightest linkage with that group. Outcomes from the lab work associated with the Center will be utilized in developing the educational materials to be tested with farmers and survey instruments focused on perceptions of climate change are shared among researchers at the Center.

III. Accomplishments

A. *Tasks Accomplished*:

Mailed Surveys. We sought and received cooperation from the Cornell Cooperative Extension offices in each of the counties where we intended to mail surveys. In March of 2005, 265 surveys were mailed in Dutchess, Ulster, Greene, Albany, Rensselaer, Schenectady and Saratoga Counties. The following March, 230 surveys were mailed to farmers in Washington County. The total number of surveys received back is the 118. Data was analyzed using SPSS.

Interviews. Our objectives for the interviews included a) gathering additional data regarding the mental model of frequencies of extreme events, b) investigating farmer decision making processes including their primary sources of information and major influences on decisions, and c) to present a simple scenario of increased frequency of extreme events (orally) and solicit their likely management response to the scenario in order to identifying their usage of the "insurance approach" versus the "diversification" approach to risk mitigation. Scheduling interviews over the summer proved to be difficult with farmers' heavy workloads. A total of approximately 30 interviews were conducted on farms over the summers of 2005 and 2006. Interviews were distributed among dairy, vegetable and fruit growers.

Workshops. Two one-day workshops were held, in January 0f 2006 in a small town in the Catskill Mountains, and in January of 2007 in Washington County at the northern edge of the study region. Farmers, several farm consultants representing Cornell Cooperative Extension and the NYC Watershed Agricultural Council attended. Both workshops were organized into three main parts: a) Introductions, overview of project and survey results (Jennifer Phillips) 2) Presentation of local climate data analysis and impacts of climate change on probabilities of extreme events (Brad Lyon), and c) Discussion on risk management. Lunch made with locally produced food was served in a hotel next door to the conference center.

B. *Key Research Results*

Farmer perceptions of climate trends

- Wet weather events identified most often as the "worst event" experienced and also as the type of event that most often causes problems. This agrees with the statistical analysis of climate trends in the Northeast.
- Some evidence of "recency" effect in which weather events of recent past dominate recollection of extremes.
- Only 20% of farmers interviewed perceive a trend in weather extremes (mostly noting floods, heavy rain), as most say the weather has always been "unpredictable".

Adaptation Measures

- A majority of farmers said "nothing can be done" to mitigate against flooding and wet weather, though man of the adaptation measures that were listed could be classified as "sustainable" (eg. improve farm drainage, diversify crops).
- Most farmers had a wide variety of measures to handle drought, but in this case, many of the measures were costly and unsustainable (such as digging more wells or destocking animals)
- We could not identify a relationship between planning horizon and type of strategies adopted – contrary to our hypothesis that farmers expecting the next generation to continue farming would use longer term strategies such as building organic matter in the soil to improve water infiltration and drought mitigation.

Identification of "resilience" to weather extremes.

- A number of the strategies were listed by farmers to mitigate against both drought and flooding. Examples include increasing the amount of land in pasture and decreasing tilled land, improving soil organic matter, or diversifying crops.
- We found these strategies to fit particularly well with the knowledge that climate change is likely to lead to greater extremes in both ends of the spectrum regarding rainfall.
- In our discussion and educational materials, we emphasized the concept of farm *resilience* to extremes.

C. *Elaboration on findings*

The general perception of trends in climate we observed on our sample of farmers is in agreement with the statistical analyses performed by us or by others. Data support the expectation that climate change is likely to lead to an increase in heavy storms, high rainfall events and longer storms in the northeastern US. However, the trends are weak, and are often not significant at the level of a single weather station. A slight majority of farmers listed rainfall as both the most important or damaging event they've ever

experienced (many identified storms in the last 5 years) and as the type of event that is generally most problematic on their farms, and some perceive an increase in these events. We believe that adaptation to high rainfall events can occur even if the farmers don't perceive or expect an increase, as long as what they are experiencing has a large impact on their operations.

It was striking that farmers had a much larger array of mitigation techniques for handling drought events. This may be due to the slow onset of droughts, allowing for time to prepare. It was of concern, however, that many of the strategies farmers use to mitigate against the impact of drought are ones that could be costly in economic terms to the farm, or may not be sustainable in a serious drought. The most commonly listed strategy for drought was to develop more water sources on the farm – i.e., dig more wells. Obviously there is a limit to how many farms and how many wells could be developed in a serious drought.

Generally speaking the strategies listed to handle flooding were ones that make better use of "ecosystem services" and are therefore less expensive and more sustainable over the long term. Diversifying crops, using the spatial variability of the landscape (i.e., plant in wet and dry areas to be prepared for either extreme), and shifting more land away from tillage into permanent pasture are just a few.. However, some of the responses were also costly and may have long term negative consequences. A good example was to buy a larger tractor so they could get onto the fields even when the soils are very wet from a storm. Heavier machinery increases soil compaction and ultimately leads to poorer drainage of fields. Improving drainage of fields often means installing tile drains, which is also quite expensive and needs to be replaced every 25 years or so.

We were struck by the number of adaptive strategies that could help to mitigate against both excess rainfall and drought conditions, and emphasized this list in our final report. Making use of spatial variability of the land, diversifying crops, increasing soil organic matter, and increasing the proportion of pasture to tilled land, all add resilience to the farming system in the face of weather extremes. We note that all these strategies fit well with sustainable agriculture in general and are keen to further explore the relationship between resilience to weather extremes and sustainable farm practices in general.

D. Presentations

A poster was presented at the U.S.Climate Change Science Program Workshop in the fall of 2005: "Farmer Climate Risk Management: Insights into Climate Change Adaptation Capacity" by Phillips, Krantz and Lyon.

Invited talk at the Hudson River Environmental Society Conference in NYC on Nov 02, 2006, "Adaptive strategies of Hudson Valley farmers to a changing climate" Phillips.

Talk at the 4th USDA Greenhouse Gas Conference in Baltimore, MD, on Feb 08, 2007, "Farmer Management of Risk Associated with Climate Extremes as Indicators of Adaptation to Climate Change", Phillips.

Invited talk at the Hunter College Geoscience Seminar Series in NYC on May 08, 2007, "Climate Risk Management by Hudson Valley Farmers: Applications to Climate Change Adaptation", Phillips.

IV. Relevance to the field of human-environment interactions

A. *Relationship of our results to the field of decision making under climate risk:*
Work by Weber (1997) with farmers in the Midwest has confirmed the idea that events recently experienced tend to be weighted more strongly in mental models of climate. We built on this work by investigating the decision sets that are based on this "near term event" bias. Furthermore, the impact of time horizon on planning and risk management was explored. Disproportionately weighting recent events may be adaptive in the face of climate change, however, clarifying response types may help in the development of support structures for the agricultural community. Improving understanding of the role of resilient strategies in the context of uncertainty in weather extremes is likely to emerge as a central theme ofclimate change adaptation.

B. *Relationship to previously funded HDGEC research*:
This work builds on previous work by the PI (Phillips) working with farmers in East and southern Africa regarding the use of seasonal climate forecasts. In that previous work the focus was on improving the communication of seasonal forecasts to farmers to promote better climate risk management strategies. Among the many lessons learned in the African context, a central one is that farmers, being more climate sensitive than many other managers, are adept at managing climate risk but have limited access to new information that is relevant to their production systems. The current work adds to our knowledge of how to present information about future climate risk for farmers here in the Eastern US. Although the timescales for forecasts differ (seasonal versus longer term), actions in the present are based on interpolations from longer term climatology and some sense of interannual varibility and our communication efforts have necessarily drawn on similar foundations.

C. Contribution to other areas of study:
This work specifically addresses the question of societal ability to adapt to climate change, and indirectly the mitigation of natural hazards. Understanding how people update their mental models of climatology, particularly regarding extreme climate events, will shed light on the potential for adopting adaptive strategies. Depending on the sensitivity of the activity, extreme climate events are often categorized as natural hazards, and decreasing our vulnerability to extreme events will help the transition in a changing climate. Although in the case of longer term climate change, climate information differs from seasonal forecasts, as is argued above, handling the variability around the trend is the difficult part and thus this work relates strongly to the work on-going in the seasonal forecast applications realm. The problem of communicating uncertainty in climate forecasts has been applied in the context of uncertainty in weather events associated with climate change. Our elucidation of the role of resilience in resource management is an important contribution of this study.

D. Suggestions for future research

Given the potential importance of the role of resilience in farming systems in adapting to increasing weather extremes, and the likely relationship of resilience to sustainable farming systems, there may be merit in comparing the adaptation strategies of organic farmers with conventional farmers. A study such as this one could be done on a larger scale with these two sets of farming systems. To investigate the issue of resilience in a specific context, one might want to look at the emerging carbon markets and the incentives for farmers to increase soil organic matter, with the associated benefits to mitigating drought and flood events. This work shows that farmers don't necessarily need to perceive trends in climate in order to be working towards creating farming systems that are buffered against climate extremes, since weather plays such a large role in their economic well-being. Thus, if progress is to be made on a large scale toward preparing society for change, the kinds of actions to be encouraged should be associated with additional benefits (carbon credits, marketing advantages, etc.) that more tangible in the present. Exploring the linkages between climate adaptation and sustainable farming systems in general is likely to bear fruit.

V. Graphics

Please see attachments

References

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